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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : B23D 61/12

A1

(11) International Publication Number: WO 99/32251

(43) International Publication Date: 1 July 1999 (01.07.99)

(21) International Application Number: PCT/US98/27288

(22) International Filing Date: 22 December 1998 (22.12.98)

(30) Priority Data:
60/068,652 23 December 1997 (23.12.97) US

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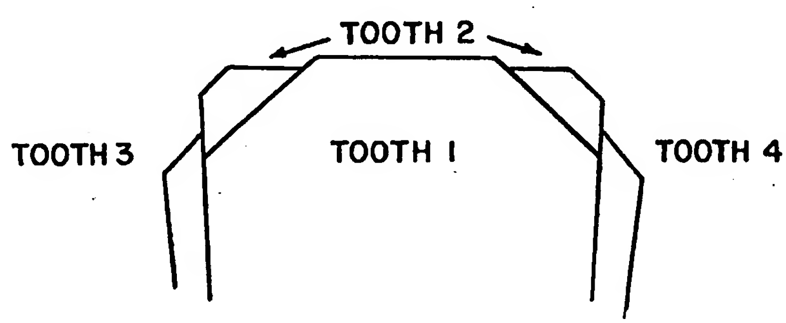
(81) Designated States: CA, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: CUTTING TOOL TOOTH FORM



(57) Abstract

Disclosed is a tooth form for cutting tools such as band saw blades, circular saws, hacksaws and other saw type products. This tooth form yields benefits such as low vibration, straight cutting, high feed rates and smoothness of cut. It is characterized by having at least two un–set teeth (1, 2) arranged with at least two set teeth (3, 4). The un–set teeth (1, 2) cut a stabilizing groove in the work piece whereas the set teeth (3, 4) widen the kerf to allow passage of the blade. The tooth pitch, tooth height, and geometry of the teeth can be either uniform or variable. The preferred embodiment has two un–set teeth (1, 2) and two set teeth (3, 4) such that five chips are formed before the pattern repeats.

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CUTTING TOOL TOOTH FORM

FIELD OF THE INVENTION

The present invention relates to a saw blade, and in particular to saw blades such as a bandsaw blade, a circular saw blade, a hacksaw blade and the like.

BACKGROUND OF THE INVENTION

In conventional saw blades, it is the usual practice, after each of the teeth have been formed at a uniform height, to set the pattern by combining teeth set in a slight bend in the direction of the thickness of the bandsaw blade (the transverse direction) with unset teeth which are not bent in the transverse direction.

When a saw blade is sawing a workpiece, chips are produced which are almost the same thicknesses as the thickness of the backing of the saw blade. This makes it very difficult to discharge these chips to the outside from the space between the groove formed by the sawing action in the workpiece and the backing of the saw blade. Specifically, the chips have a tendency to collect in the gullet formed between the teeth of a conventional saw blade. Once this gullet is filled with chips, these chips cause the saw blade to be elevated in the feed direction of the cut relative to the workpiece. In proportion to the amount by which the saw blade is elevated, it produces a course deviation to the right

or left relative to its direction of travel. Accordingly, in conventional saw blades the problem is produced by which the cut veers to the direction of the deviation.

In addition, in conventional saw blades, when the blade continues to cut the workpiece after chips have collected in the gullet, the chips are compressed so that the problem arises whereby the pressure of the chips cause breakage of the saw teeth. In conventional saw blades, although there are slight differences in height between the tips of the unset teeth and the tips of the oppositely set teeth, for example, when taken from the locus of the center of the thick portion of the unset teeth, the tips of each tooth are almost the same height. Therefore, when the workpiece is being cut, the unset teeth are not always the first teeth to cut into the workpiece. The oppositely set teeth can also be the first to cut into the workpiece. For example, when the left-set teeth are the first to cut into the workpiece, the cutting resistance causes the saw to have the inclination to swing to the right side. Specifically, there is the problem in a conventional saw that vibration and deviation of the cut in the transverse direction is easily produced.

Moreover, the productivity rates desired in cutting of materials have been continually increasing. This increase in productivity has generally been accomplished by using higher cutting speeds or greater down feed pressures (cutting rates). These conditions impose greater demands on the cutting blades. As speeds increase harmonic vibrations within the blade cause teeth to become damaged, high sound levels, and irregular cuts.

In order to meet the production demands of those who need high cutting rates, products are required which will cut quietly with minimum vibration yet at high speeds. Carbide tip products have been introduced which allow for greater loading of the teeth and greater speeds, but top speeds are limited by vibration of the saw. A tooth form is needed which will minimize vibration of the saw, allow high feed rates, maintain a straight cut and yield a smooth cut surface.

PRIOR ART REFERENCES

The following patents are related to the present invention as background information:

4,011,783	Mar. 15, 1977	Circular Saw
4,423,553	Jan. 3, 1984	Blade for a Saw...
4,557,172	Dec. 10, 1985	Saw Blade
4,727,788	Mar. 1, 1988	Saw Blade
4,813,324	Mar. 21, 1989	Saw Blade
4,827,822	May 9, 1989	Saw Blade
5,331,876	Jul. 26, 1994	Saw Blade...
5,425,296	Jun. 20, 1995	Saw Blade
5,477,763	Dec. 26, 1995	Saw Blade
5,603,252	Feb. 18, 1997	Saw Blade
WO 98/07545	Feb. 26, 1998	Tooth Structure...
5,832,803	Nov. 10, 1998	Tooth Structure...

SUMMARY OF THE INVENTION

It is therefore an object of this invention to provide a blade that has reduced vibration. It is also an object of this invention to provide a blade that will allow high feed rates and high speed of cutting.

It is a further object to provide a blade that maintains a straight cutting path. It is another object to provide a blade that has an improved surface finish on the cut surface.

This invention thus provides a novel tooth form consisting of a combination of at least two un-set teeth and at least two set teeth. The two un-set teeth are of different height and cut a channel, which stabilizes the cutting

blade. The two set teeth are positioned to clear a kerf channel to allow for passage of the blade. The teeth are positioned in such a way as to minimize vibration of the cutting blade. Several benefits result from this invention including a quite operation, enhanced straightness of the cut and a smooth cut surface.

The unique feature on this tooth form is the use of two unset teeth, the first tooth being the highest followed by one that is lower, but wider. Two set teeth that serve to widen the kerf follow these two unset teeth.

In especially preferred embodiments of the present invention, one or more of the following modifications may be employed to enhance the performance of the tooth form described herein:

(a) chamfer one or more of the teeth, especially the set teeth, for improved surface finish;

(b) side grind a clearance into one or more of the teeth, to provide more efficient cutting;

(c) the highest tooth can be made wider than the next highest tooth, to provide smoother cutting and less noise;

(d) the flat portion of the highest tooth may advantageously be more than 1/3 the width of the tooth, thereby providing greater strength and resistance to breakage.

One or more of these modifications can likewise be used to improve the above-described prior art tooth forms; especially those disclosed in U.S. 4,827,822 and WO 98/07545.

Thus, the present invention includes a tooth form comprising two high guiding teeth followed by one or more sequences of set teeth which are either in pairs or other arrangements, and which optionally include varying set magnitudes and varying number of teeth.

The present invention will serve as the tooth form for a new range of carbide products, including a variable tooth carbide tip product, as well as ground tooth bimetal products including power hacksaw blades and circular saw blades.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1, in views A, B and C, show typical grinding profiles for the teeth used in the invention. View A shows the grinding profile of un-set tooth 1. View B shows the grinding profile of un-set tooth 2. View C shows the grinding profile of the set teeth 3 & 4.

Figure 2, in views A and B, illustrates the preferred geometry of set tooth 3 (View A) and set tooth 4 (View B) after being set. Note - these could be reversed.

Figure 3, in views A and B, illustrates the preferred relationship of the tooth profiles to one another. This relationship provides the desired PENTA-CHIP™ formation during cutting.

Figure 4, in views A and B, illustrates the preferred tooth form in both plan (View A) and top views (View B).

Figure 5, in views A and B, illustrates further improvements to the preferred tooth form.

Figure 6, in views A, B, C, and D, shows preferred tooth profiles, chamfer angles, side grinding angles, and other specific preferred tooth form details.

Figure 7, in views A and B, shows another embodiment of the present invention, an even pitch, variable pitch 1.4-1.8 carbide tip tooth form.

Figure 8, in views A and B, shows another embodiment of the present invention, an even pitch, variable pitch 2-3 carbide tip tooth form.

Figure 9, in views A and B, shows another embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is illustrated in the Figures accompanying this specification. As illustrated therein, this invention covers a special tooth form that is composed of at least two un-set and at least two set teeth arranged so that the un-set teeth cut a channel in the work piece. This channel enhances stability of the blade much the same as a rudder on a ship. The set teeth, in turn clear the kerf for passage of the blade. The use of more than one un-set tooth and having these un-set teeth at various heights and rake angles allows the blade to cut efficiently in a variety of materials.

The variable heights and variable rake angles also permit the blade to cut in a fashion which minimizes vibration of the blade which is detrimental to performance when using hard materials such as carbide. The use of set teeth to clear the kerf area allows for more clearance angle than can normally be achieved through grinding a carbide tip and thereby allows for a smooth cut surface.

The preferred embodiments of the invention have a group of two un-set teeth ground so that the second tooth in the group is lower and wider than the

first tooth in the group. This group of un-set teeth is immediately followed by a group of two set teeth, which are of the same shape and height. The height of these set teeth are lower than either of the two un-set teeth and the set magnitude allows the teeth to extend beyond the widest of the two un-set teeth. One or more of these teeth are side ground such that the widest portion of the tooth is greater than the thickness of the blade. This arrangement results in forming five chips before repeating. Figure 3 shows the preferred overlay of teeth and the five chip, or PENTA-CHIP™, formation.

Figures 5 and 6 show modifications to the preferred PENTA-CHIP™ blade design. The specific changes were to increase the flat portion of the highest tooth from 0.017" to 0.022", and to change the height difference between tooth 1 and 2 from 0.002" to 0.0053". These changes match the volume of chips generated by cutting to the volume of the gullet, and will allow for optimum cutting rates. Figures 7-9 show additional embodiments of the blade design.

Further Blade Modifications:

Many cutting blades rely upon setting the teeth to expose the tooth tips and allow efficient cutting. Setting the teeth also serves to cut a width (called "kerf") which is greater than the thickness of the blade and thereby allow more efficient passage of the blade body through the work. Prior art shows arrangements of these set teeth wherein the magnitude of displacement from the side of the blade varies and creates a broaching type of functionality as the kerf generated by the blade is made wider (see, U.S. Patent No. 4,727,788 and U.S. Patent No. 4,813,324).

When setting the teeth of a blade it is common to encounter variations in the magnitude of set and the angle of the set tooth. These variations occur due to minor differences in position of the tooth during setting, variations present in the milling cut that generates the tooth pitch, variations in the mechanical properties of the material, variations in the geometrical characteristics of the

blade, variations in the milling cutters used to generate the tooth form, or variations in the setting operation itself. This multitude of variations reduces the chance that the cutting blade will be made to the intended cutting geometry.

One method, which can reduce these variations, involves the use of grinding to generate the required tooth geometry. Grinding is used in high performance products such as a standard triple chip product (see, U.S. Patent No. 4,011,783) to various custom ground configurations (see, U.S. Patent No. 5,425,296 and U.S. Patent No. 5,477,763). While grinding usually increases the cost of the blade it is effective in reducing variability. This generally increases performance consistency and precision.

A combination of grinding and setting has been used to create blades that will clear a larger kerf than would be permitted with a blade that is only form ground. This type of tooth form (see U.S. Patent No. 5,331,876) is still susceptible to the same types of variability mentioned above for standard set type product.

Patents pertaining to the use of grinding to create tooth forms on cutting blades have been generally restricted to creating blades which have symmetrical profiles when the cutting tooth is viewed from the front of the tooth. Exceptions to this statement occur with ground tooth forms such as those shown in U.S. Patent No. 4,423,553 which combines a ground or filed tooth form with setting of this tooth to create a wide cutting kerf. In some cases, this ground tooth has been combined with relief grinding of the blade such as is seen with standard ground relief jigsaw blades.

Accordingly, the skilled artisan will appreciate the fact that further improvements in performance can be achieved through greater precision in the manufacture of the product. In addition, performance improvements have been obtained using arrangements of teeth, which cut preferred portions of the

workpiece. Ground tooth forms that cut designated chips or areas of the kerf will provide cutting consistency and precision benefiting the end user.

EXAMPLES

Three blades were tested for cutting rate, noise and surface finish generated during cutting under the following conditions:

Machine	Daito
Downfeed Setting	Varied 3 to 6
Tension Setting	18
Speed	112 SFPM (unless modified as noted)
Coolant	Standard (10%)
Test Material	T304 – 4¾-inch diameter ground stainless
steel bar	

This testing showed that the 1½-inch 2.5/3.5 PENTA-CHIP™ blade design was quieter than two commercially available comparison blades (CTIII 1½ inch 2TPI and 1½ inch 2 3MR – Simonds Industries, Inc.) as speed was increased.

The CTIII blade cut quietly but had shadowing of the set pattern on the cut surface. Noise was good at 112 SFPM and 138 SFPM but was quite loud and unacceptable when run at 171 SFPM.

The 3MR blade had some squealing on the cuts, which could be due to a lack of break in. The noise was considerable at the 171 SFPM speed setting and would be unacceptable in production.

At 171 SFPM the PENTA-CHIP blade was generally as quiet as the machine. It was noted that when the PENTA-CHIP blade made noise it was for very short time periods (usually only a second or two). Two additional runs

were made, one at a lower speed (90 SFPM), which was exceptionally quiet and another at a higher speed (210 SFPM), which was much quieter and tolerable when, compared to the 3MR.

The set teeth on the PENTA-CHIP blade were face ground (7 degrees) before setting. This presents a negative face angle to the cut, which is not commonly used when cutting stainless steel. Ideally, face grinding will be done after setting. The cutting times for the PENTA-CHIP were still better than the comparison bands. After face grinding this blade, it was run at speeds from 90 SFPM to 210 SFPM and was as quiet as the machine at all speeds. Feed rate was varied and did not affect noise of the band. The quality of the cut surface was excellent.

Comparison of 3MR product to PENTA-CHIP Product

The table below compares important geometric features of the 3MR tooth form to the PENTA-CHIP tooth form:

Geometrical Parameter	*3MR Product*	*Special Titanium Grind*	*PENTA-CHIP Grind*
Face Rake Angle	6°	10°	7°
Primary Back Angle	20°	14°	22°
Secondary Back Angle	40°	40°	45°/52°
High-Low height Diff	.003"	.007"	.002"

The PENTA-CHIP design can thus be considered a "next generation" of the Simonds 3MR product. The two highest teeth in the PENTA-CHIP design do most of the cutting while the two set teeth serve to only widen the kerf to allow easy passage of the blade through the work. Due to this unique cutting arrangement, the effective pitch of the PENTA-CHIP blade is considerably coarser than one would expect upon initial examination. The 2.5/3.5 pitch, which has 4 teeth in a 1.407 distance, would normally be considered to have an

effective tooth pitch of 2.8 TPI. However, the two set teeth cannot be considered cutting teeth which leaves the cutting rate and aggressiveness of the blade related to the two high teeth. This implies that the blade will have the cutting action of 2 teeth in the repeat length for an effective pitch of 0.7 TPI.

One advantage of the PENTA-CHIP over the 3MR product arises from the infeed moderating effects caused by the set teeth. Whereas a coarse pitch blade like the 0.7 TPI mentioned above would feed without much control particularly in thin sections, the PENTA-CHIP product will have an additional two teeth in the work to prevent a feed rate that would damage the blade. This feed control could be adjusted by changing the primary back angle of the set teeth (teeth 3 and 4) or through the use of more pairs of ground and set teeth.

A negative effect also occurs due to this unique design. The wear rate or effective service life of the blade is determined by the wear rate of the two high teeth. It is known that a blade with more cutting teeth will offer greater overall life at the sacrifice of cutting speed. The PENTA-CHIP blade would be expected to have the life of a carbide tip 3MR blade having a pitch of 7 TPI. However, because of the increased number of teeth due to the set teeth, it can be used in applications where such a coarse pitch would be prohibitive.

CHROME/COBALT CUTTING TEST

One PENTA-CHIP™ band of 1-1/2" x .055 2.5/3.5 18'10-1/2" was tested on a Cosen AH-2028H Bandsaw. The band had been face ground to 7 degrees, after setting.

The testers noted that prior to this cutting test, they had never had a blade cut the Chrome with Cobalt Experimental materials as fast (19 minutes). When lightly loaded the PENTA-CHIP™ blade tended to squeal, but when loaded it quieted down.

GULLET VOLUME STUDIES

Area calculations on the gullet of the PENTA-CHIP™ tooth form are shown below. In order to optimize performance of this product, it is believed that the volume of the chip made by each tooth (Chip area x gullet length) should be related to the gullet volume (gullet area x band thickness).

Such ratios have been calculated for the 0.002-inch difference between the high tooth to the lower tooth that was used for early versions of the PENTA-CHIP product. Next such ratios were calculated for a theoretical optimum difference of 0.007 inches.

Relationship between Chip Volume and Gullet Volume
For two variations of the 2.5/3.5 PENTA-CHIP Tooth Form

The following calculations are based upon a 0.002-inch difference in height between tooth 1 and tooth 2:

Tooth No.	1	2	3	4
Chip Volume	0.0000446	0.0000661	0.0000075	0.0000087
Chip Vol Ratio	100.0%	148.1%	16.8%	19.5%
Gullet Volume	0.0019952	0.0015508	0.0008075	0.0010905
Ratio	100.0%	77.7%	40.5%	54.7%

The following calculations are based on a 0.007-inch difference in height between tooth 1 and tooth 2:

Tooth No.	1	2	3	4
Chip Volume	0.0000659	0.0000472	0.0000075	0.0000087
Chip Vol Ratio	100.0%	71.7%	11.4%	13.2%
Gullet Volume	0.0019952	0.0015508	0.0008075	0.0010905
Ratio	100.0%	77.7%	40.5%	54.7%

These calculations suggest that much more set can be put on the product without fear of filling the small gullets, or conversely, that modifications could be made on tooth cutting.

The present invention has been described in detail, including the preferred embodiments thereof. However, it will be appreciated that those skilled in the art, upon consideration of the present disclosure, may make modifications and/or improvements on this invention and still be within the scope and spirit of this invention as set forth in the following claims.

WHAT IS CLAIMED IS:

1. A tooth form for cutting tools comprising at least two sequential un-set teeth followed by at least two sequential set teeth, the first un-set tooth being higher than the second unset tooth; the second un-set tooth being lower, but wider than the first unset tooth; whereby the un-set teeth cut a stabilizing groove in the work piece and wherein the set teeth widen the kerf to allow for passage of the blade.

2. The tooth form of Claim 1, wherein the tooth pitch is uniform.

3. The tooth form of Claim 1, wherein the tooth pitch is variable.

4. The tooth form of Claim 1, wherein the set tooth height is uniform.

5. The tooth form of Claim 1, wherein the set tooth height is variable.

6. The tooth form of Claim 1, wherein the set tooth geometry is uniform.

7. The tooth form of Claim 1, wherein the set tooth geometry is variable.

8. The tooth form of Claim 1, wherein the cutting tool is a circular saw blade.

9. The tooth form of Claim 8, wherein the blade is a carbide blade.

10. The tooth form of Claim 8, wherein the blade is a bimetal blade.

11. The tooth form of Claim 1, wherein the cutting tool is a band saw blade.

12. The tooth form of Claim 11, wherein the blade is a carbide blade.

13. The tooth form of Claim 11, wherein the blade is a bimetal blade.

14. The tooth form of Claim 1, wherein the cutting tool is a power hacksaw blade.

15. The tooth form of Claim 14, wherein the blade is a carbide blade.

16. The tooth form of Claim 14, wherein the blade is a bimetal blade.

17. A tooth form for cutting tools comprising two un-set teeth followed by two set teeth; the first un-set tooth being the highest and the second un-set tooth being lower, but wider than the first unset tooth; said tooth form forming five chips before the tooth form pattern repeats.

18. The tooth form of Claim 17, wherein the tooth pitch is uniform.

19. The tooth form of Claim 17, wherein the tooth pitch is variable.

20. The tooth form of Claim 17, wherein the set tooth height is uniform.

21. The tooth form of Claim 17, wherein the set tooth height is variable.

22. The tooth form of Claim 17, wherein the set tooth geometry is uniform.

23. The tooth form of Claim 17, wherein the set tooth geometry is variable.

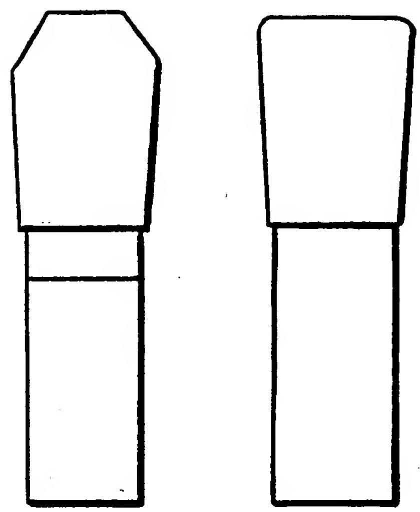


FIG. 1A FIG. 1B FIG. 1C

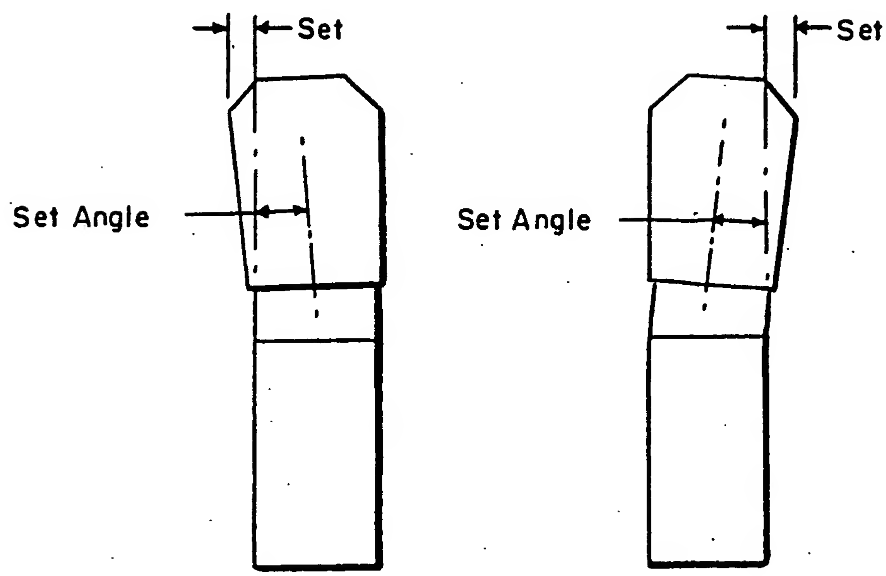


FIG. 2A FIG. 2B

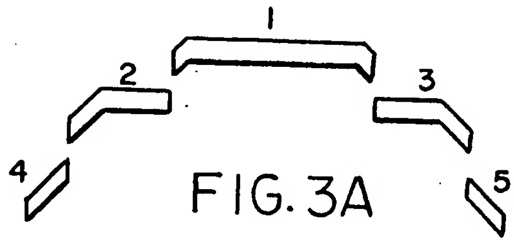


FIG. 3A

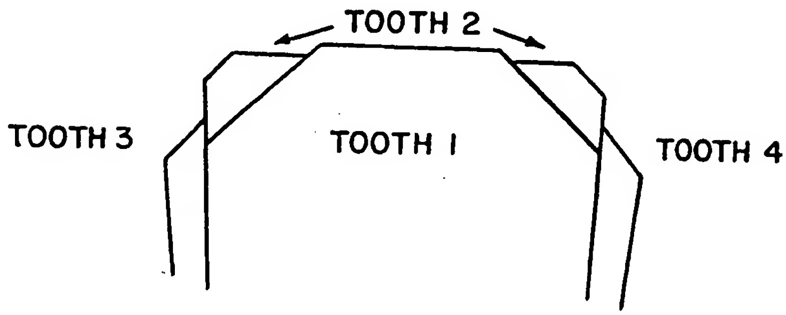


FIG. 3B

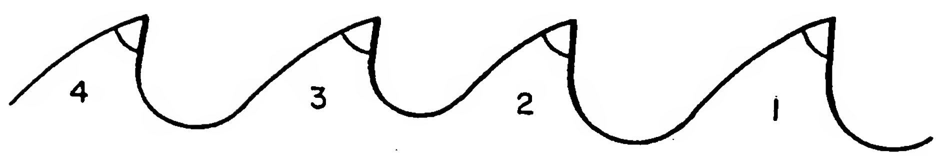


FIG. 4A

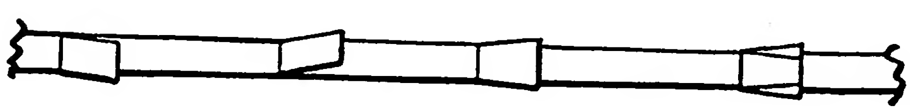
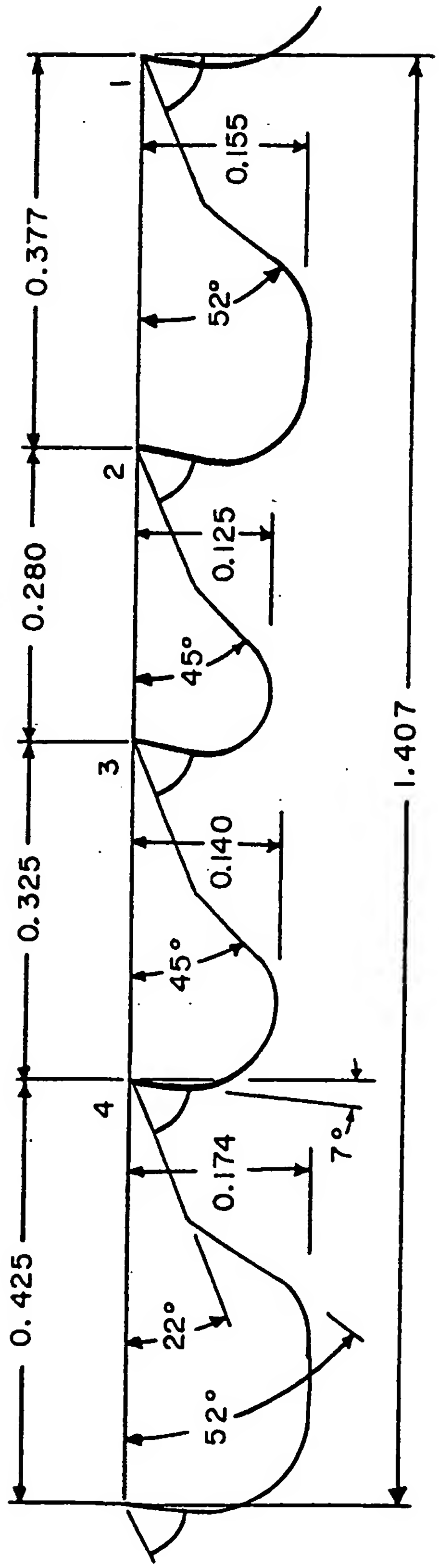


FIG. 4B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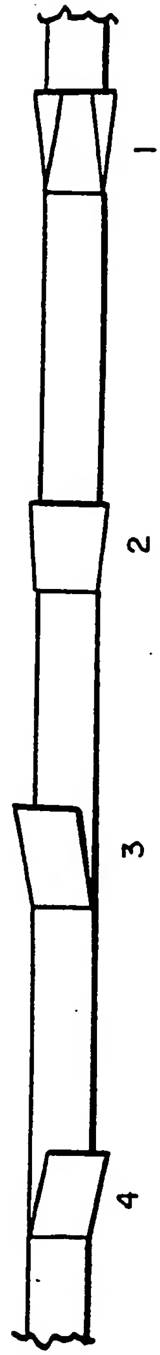
52°
7°

FIG. 5A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2
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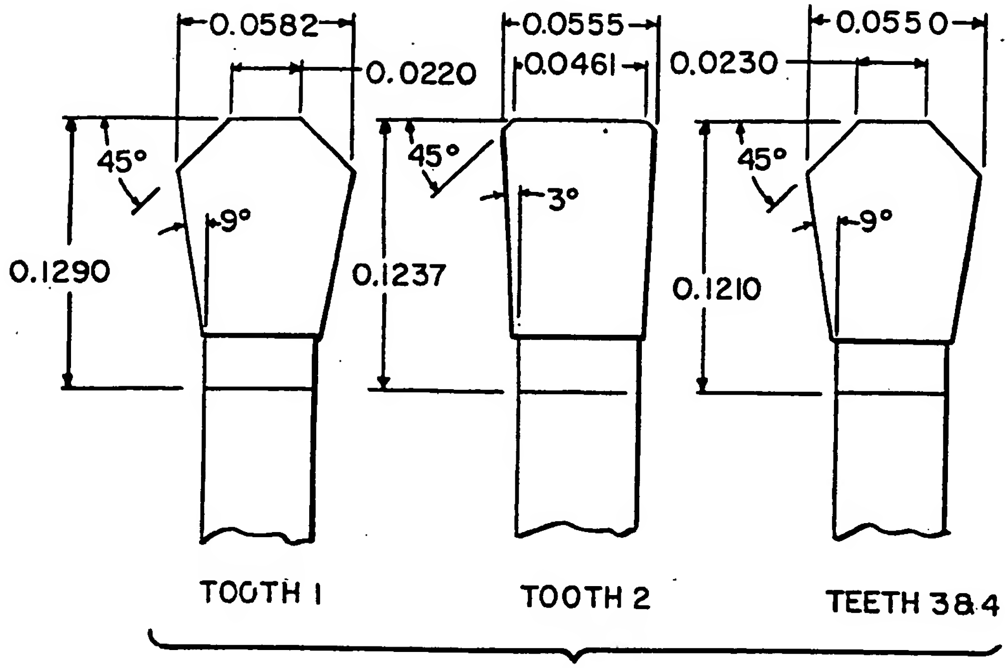
4

FIG. 5B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3°
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0.1210
TOOTH 1
TOOTH 2
TEETH 3&4

FIG. 6A

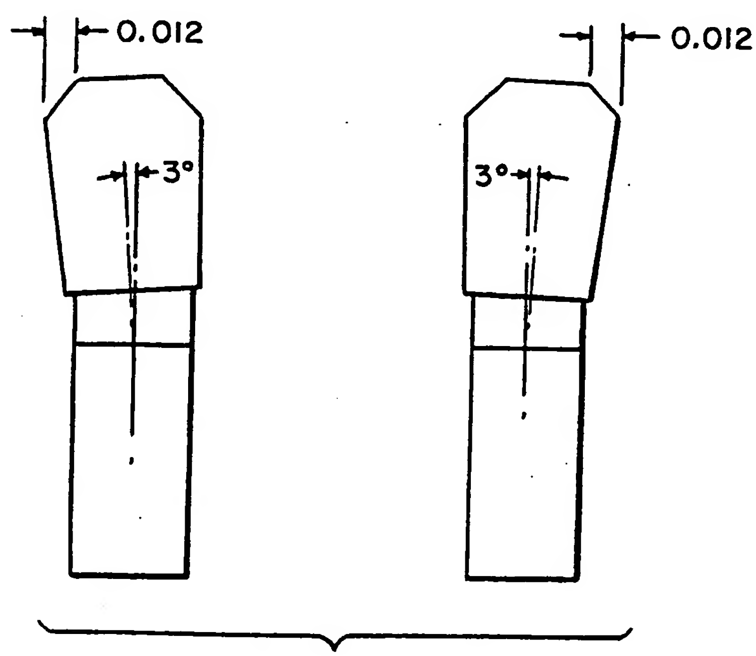
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FIG. 6B

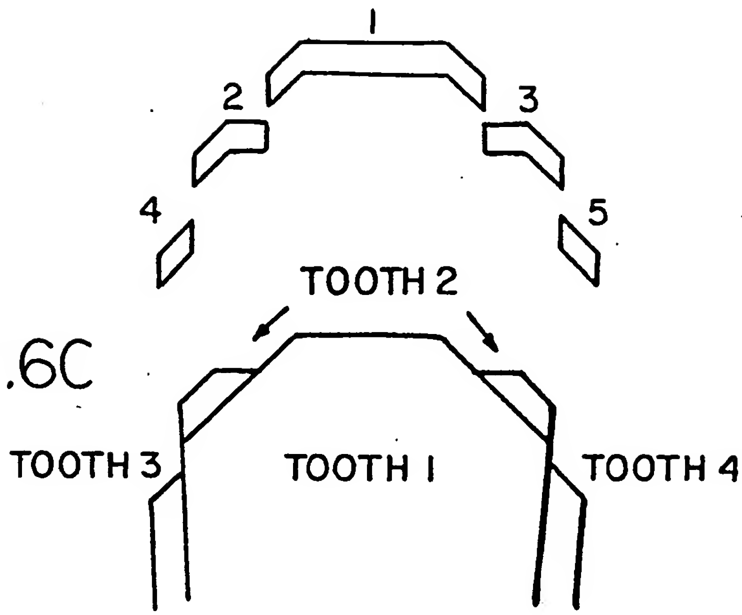


FIG.6C

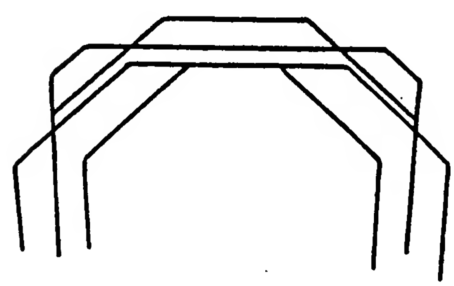
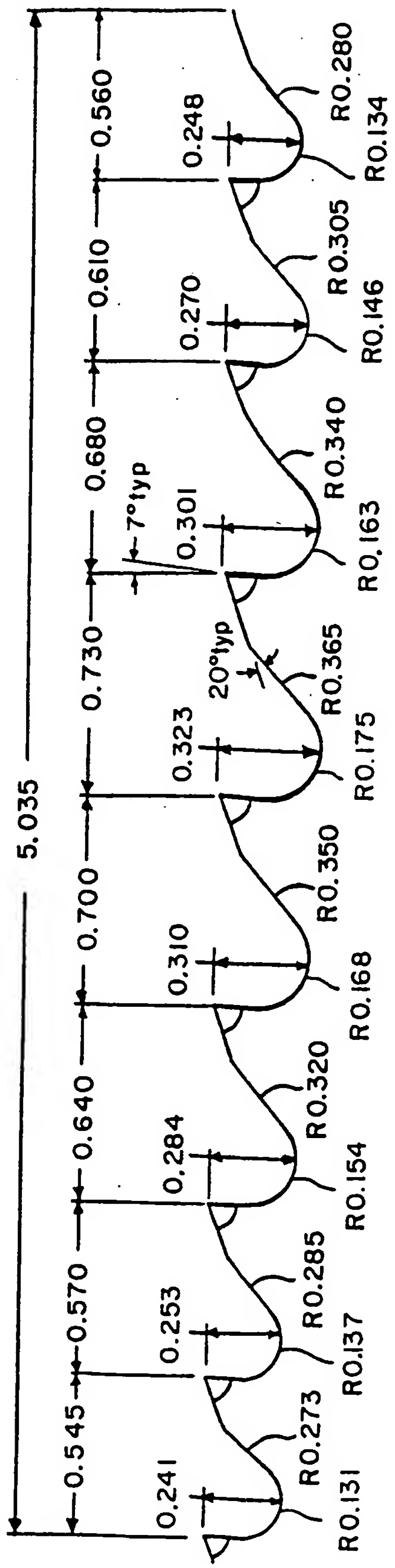


FIG.6D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0.323
0.310
0.284
0.253
0.241
7° typ
20° typ
R0.280
R0.134
R0.305
R0.146
R0.340
R0.163
R0.365
R0.175
R0.350
R0.168
R0.320
R0.154
R0.285
R0.137
R0.273
R0.131

FIG. 7A

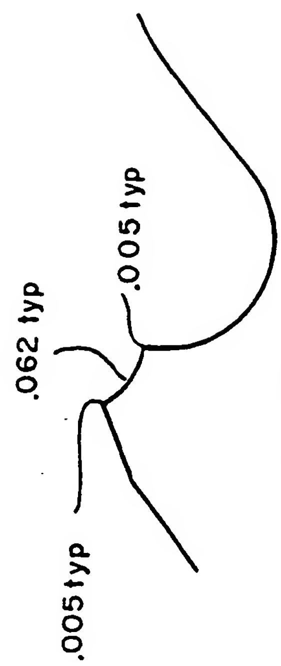
.062 typ
.005 typ
.005 typ

FIG. 7B

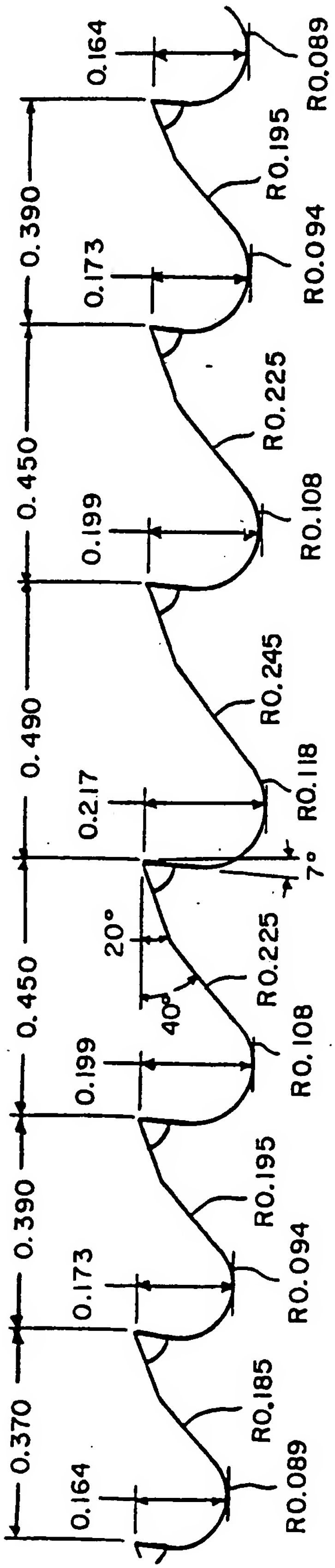
0.164
R0.089
0.390
R0.195
0.173
R0.094
0.450
R0.225
0.199
R0.108
0.490
R0.245
0.217
R0.118
7°
20°
40°
0.450
R0.225
0.199
R0.108
0.390
R0.195
0.173
R0.094
0.370
R0.185
0.164
R0.089

FIG. 8A

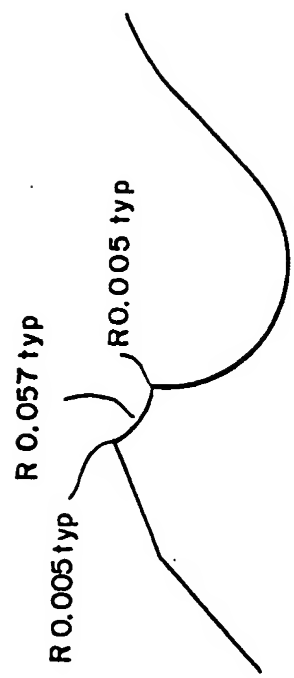
R 0.057 typ
R0.005 typ
R0.005typ

FIG. 8B

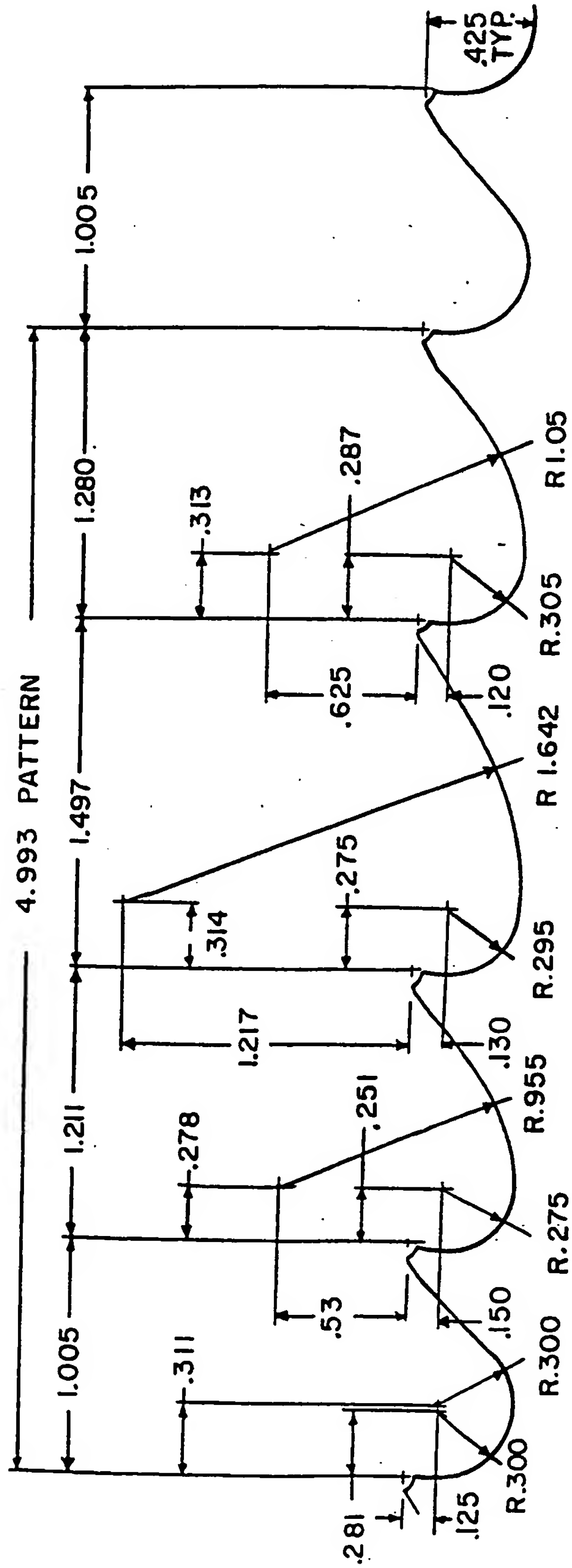
.425 TYP.
1.005
1.280
1.497
1.211
1.005
4.993 PATTERN
.313
.287
R 1.05
.625
.120
R.305
.275
R 1.642
.314
1.217
.130
R.295
.278
.251
R.955
.53
.150
R.275
.311
.281
.125
R.300
R.300

FIG.9A

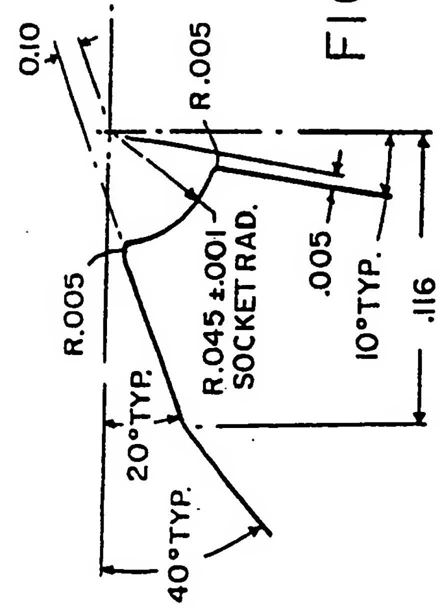
0.10
R.005
R.005
R.045 ±.001 SOCKET RAD.
.005
10°TYP.
.116
20°TYP.
40°TYP.

FIG.9B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/27288

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :B23D 61/12
US CL : 83/835
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 83/835, 661, 848, 849, 850, 851, 852, 846

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,425,296 A (KULLMANN ET AL) 20 JUNE 1995, see entire document, especially col. 1, col. 8, and col. 9.	1-7, 11, 17-23
Y	US 4,827,822 A (YOSHIDA ET AL) 09 MAY 1989, see entire document.	8, 14
Y, P	US 5,832,803 A (HAYDEN, SR.) 10 NOVEMBER 1998, col. 1, lines 6-45, col. 2, lines 29, et seq., col. 3 and col. 4.	1,3-4, 7, 17, 19-20
Y	US 4,784,033 A (HAYDEN ET AL) 15 NOVEMBER 1988, see entire document, especially col. 1-2, and 4-8.	9-13, 15-16
A	US 5,477,763 A (KULLMAN) 26 DECEMBER 1995, col. 1, col. 2-9.	1-7, 11, 17-23

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 MARCH 1999	26 MAR 1999

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